SYNTHETIC STUDIES, PHOTOPHYSICAL AND BIOLOGICAL PROPERTIES OF NITROGEN AND SULPHUR HETEROCYCLES

SYNOPSIS

OF THE Ph.D. THESIS

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IN
INDUSTRIAL CHEMISTRY

BY

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SYNTHETIC STUDIES, PHOTOPHYSICAL AND BIOLOGICAL PROPERTIES OF NITROGEN AND SULPHUR HETEROCYCLES

(Synopsis of the Ph.D. Thesis of Mr. PRAVEENA P. to be submitted for the award of Ph.D. degree under the Guidance of Prof. B.K. Sarojini, Department of Industrial Chemistry, Mangalore University, Mangalagangothri-574199)

Introduction:

Heterocyclic chemistry is a branch of chemistry that deals with the properties, synthesis and applications of heterocycles. A cyclic compound is that which contains a ring of atoms. Aromatic heterocycles are planar rings of atoms containing at least one non-carbon atom N and S. A vast number of different classes exist, in that thiophene based chalcones, pyrazoline and thiozole ring compounds possess interesting pharmacological, biological activities and photo-physical properties which included antioxidant, anti-malarial, analgesic, anti-inflammatory, anticancer, antifungal, antibacterial and are also used as pesticides: herbicides, fungicides, insecticides, rodenticides and fluorescence materials, ionic liquids, dyes and pigments. There are several established methods for their synthesis. This research work aims at highlighting these very diversities of these ring compounds and the eco-friendly method by which they could be synthesized.

The present study entitled “Synthetic studies, photophysical and biological properties of nitrogen and sulphur heterocycles” has been deliberated in six chapters.

Objectives of research work:

- To synthesize and characterize chalcone derivatives by mechanochemical method
- To synthesize and characterize pyrazoline derivatives
- To synthesize and characterize thiazole derivatives
- To study the spectral characteristics by, FT-IR, ^{1}H /^{13}C-NMR, LC-MS and single crystal-XRD techniques.
- To analyze photo-physical properties (UV-Visible and Fluorescence)
- To evaluate *in vitro* antioxidant and anti-inflammatory activities synthesized compounds

CHAPTER 1: A BRIEF REVIEW ON THE CHEMISTRY OF CHALCONE, PYRAZOLINE AND THIAZOLE DERIVATIVES AND THEIR IMPORTANCE

This chapter affords a brief review on the methods of synthesis and photophysical, biological applications of chalcone, pyrazoline and thiazole derivatives.

Chalcone derivatives:

Chalcones are significant group of flavonoids present in naturally occurring plant species. Chalcones (1, 3-diphenyl-2-propen-1-ones) are three carbons α, β-unsaturated carbonyl group with two aromatic rings. The chalcones derivatives were synthesized by conventional and green methods for its chemically and biologically active scaffolds [1-5]. These natural products and synthetic compounds are finding their application as potential antiviral [6], anticancer [7], antioxidant [8], antimalarial [9], antimicrobial [10], anti-inflammatory [11] and antifungal [12] agents. Also, these, β-unsaturated carbonyl system of chalcones are emerging as promising analogues for light-sensitive materials and optical properties [13-14]. Besides, these are also used as intermediates for the synthesis of various heterocyclic compounds like isoxazolines [15], pyrazolines [16-21], thaizole [22], pyrazoles [23] derivatives could be leads as potential drug candidates. The some

literature reports demonstrating that chalcones are show several interesting biological properties. In chalcone derivatives possess chemopreventive and antitumoural activities [24], metochalcone is used as choleretic and diuretic agent [25], chalcone leads to hybrid pyrazoline derivatives for antibacterial, antioxidant and anti-inflammatory active scaffolds[26], chalcone analogues shows different antimicrobial effects against all the bacterial species [27],the antioxidant property and anticancer activity of chalcone derivatives are reported [28], In addition, photophysical properties of chalcone analogues are reported in literature. The absorption and fluorescence characteristics of chalcones are investigated [29], the chalcone analogue is used as dyes emitting organic sensor [30].

Pyrazoline derivatives:

Pyrazoline derivatives are very valuable nitrogen containing heterocyclic compounds for their chemical and biological properties. In the past decade, pyrazoline derivatives were mostly investigated for photo-physical properties such as fluorescent brightening agents [31], organic light-emitting diodes (OLEDs) [32], and also widely used as pharmacological active scaffolds with various biological properties [33-37]. Pyrazoline derivatives were synthesized by various synthetic and eco-friendly protocols. An especially prominent procedure for the synthesis is based on the reaction of $\alpha,\beta-$ unsaturated ketones with some substituted hydrazine under different conditions [38-41].The some literature reported that pyrazoline derivatives are shows several interesting biological and photo physical properties. The thiophenyl pyrazoline moiety was reported as potential antidiabetic and anticancer agents [42], pyrazoline analogues was synthesized and screened for antimicrobial activity [43], pyrazoline derivatives were evaluated for *in vitro* antibacterial activity [44], pyrazoline core compounds are designed

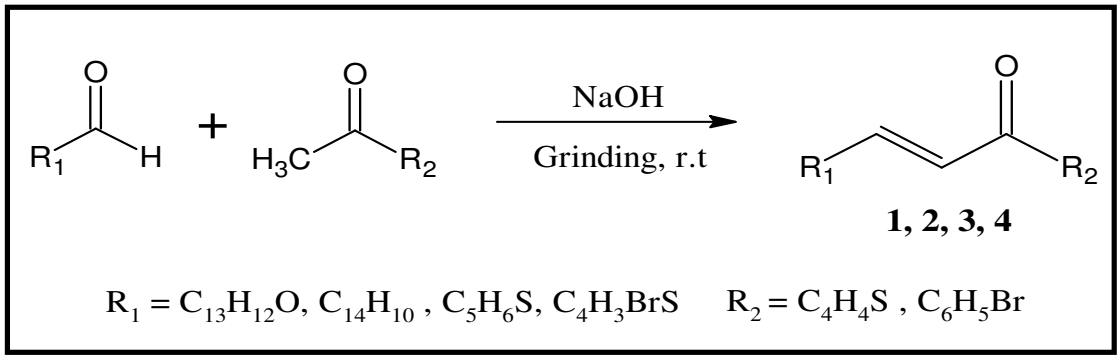
as fluorescent materials, synthesized and characterized by various approaches [45], the pyrazoline moiety were evaluated as fluorescence dyes and studied its quantum yield [46].

Thiazole derivatives:

A heterocyclic ring integrated with nitrogen and sulphur such as thiazole have been extensively studied based due to their synthetic and biological applications. Thiazole is the most commonly reported compound in the literature. Thiazole is a 5- membered ring moiety containing nitrogen and sulphur at position 1 and 3, respectively. The structural pattern of thiazole derivatives as active compounds is predominantly focused on the substitution of hydrogen atoms with desired moieties at position 2, 4, 5. The derivatives were biological activities anti-inflammatory [47], antifungal [48], anticancer [49], antibacterial [50] and antitumor [51]. The literature reported that hybrid thiazole derivatives as potential candidates for drug discovery prospect. So some reported thiazole derivatives were documented as anticancer agent [52], the thiazolidinone – pyrazoline hybrids developed as potent antimicrobial target [53], thiazole derivative tested for their anticancer activity [54] and also some thiazole hybrid moiety used as fluorescent probe [55], fluorescent thiazole–pyrazoline derivative's series were used as anticancer target [56], thiazole derivatives used as fluorescent Sensing of biomolecules and ions [57].

Hence, it was decided to synthesize thiophene based chalcones and its derivatives like pyrazoline and thiazole analogues to study its biological and photophysical properties.

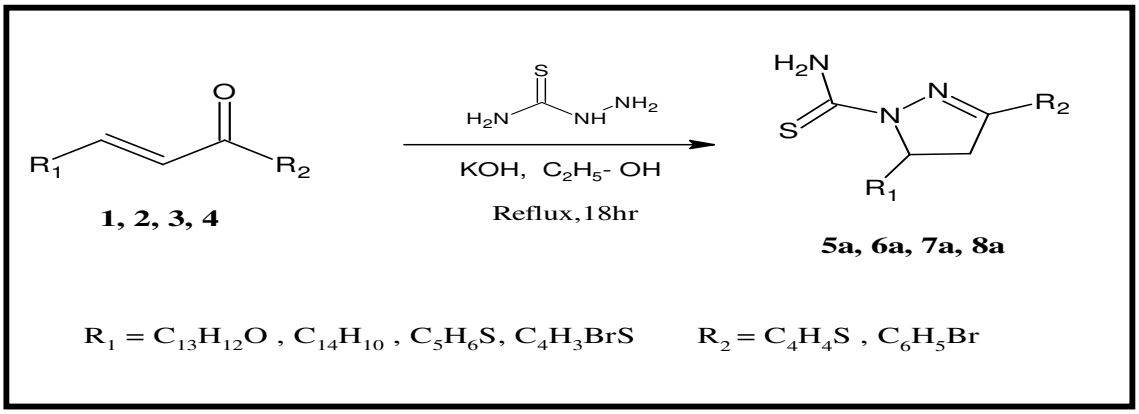
CHAPTER 2: STUDIES ON SYNTHESIS AND CHARACTERIZATION OF THIENYL CHALCONE AND N-THIAMIDO PYRAZOLINE DERIVATIVES



Scheme 2.1: Synthesis of thienyl chalcone derivatives

In this chapter, synthesized the thienyl chalcone derivatives (**1-4**) by a mechanochemical method. The reaction undergoes with substituted aldehydes and substituted acetophenone with sodium hydroxide were grinded for 5 minutes without solvent. The formations of the synthesized compounds were confirmed by FT-IR, ^{1}H NMR, ^{13}C NMR and LC-MS spectral data analysis. The single crystal XRD, Hirshfeld surface analysis of chalcone derivatives **1** and **2** were carried out.

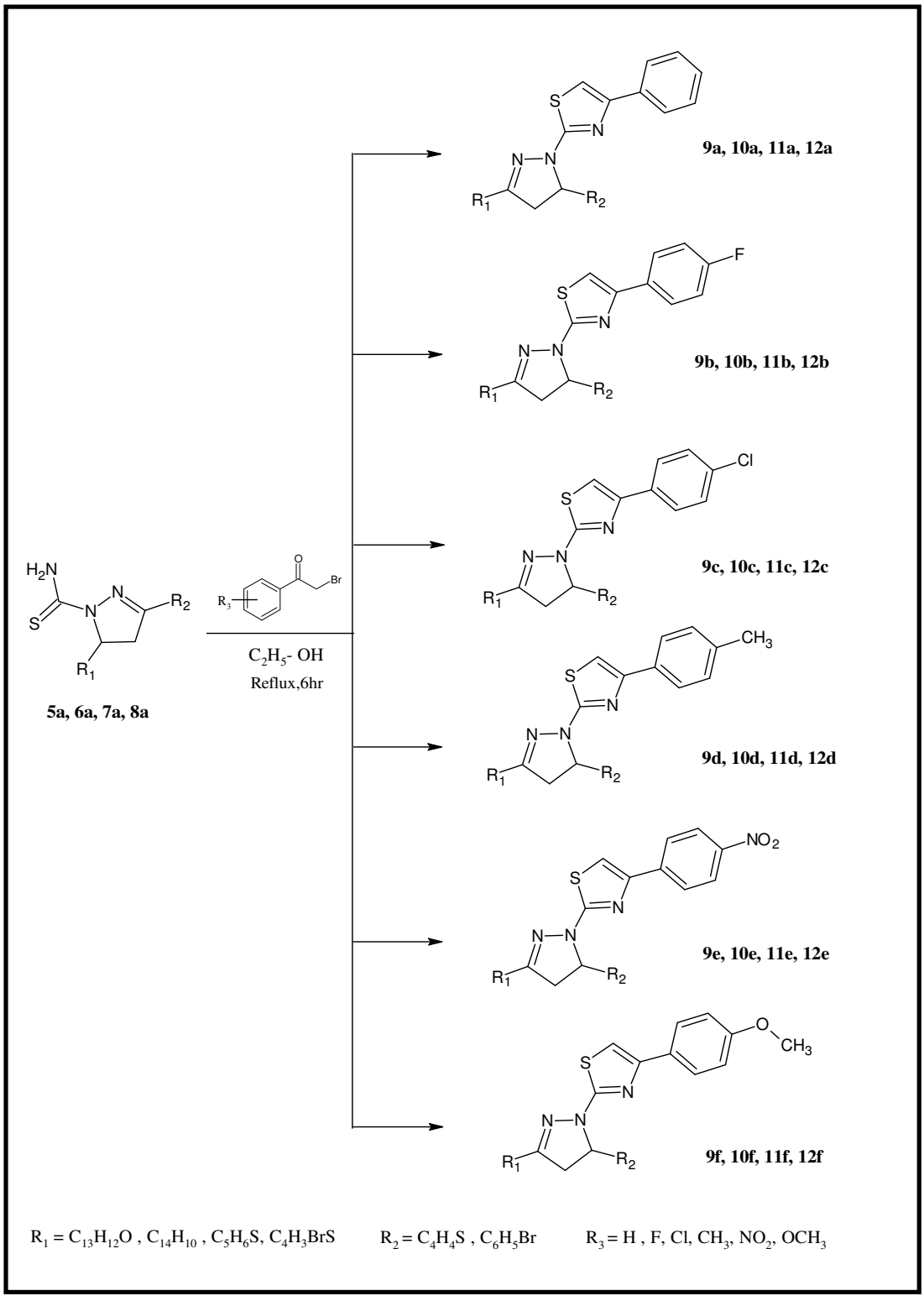
In this chapter, synthesized the N- thioamido pyrazoline derivatives (**Scheme 2.2**) by, chalcone derivatives and thiosemicarbazide in ethanolic KOH and refluxed for 18 hrs. The formations of the synthesized compounds were confirmed by FT-IR, ^{1}H NMR, ^{13}C NMR and LC-MS spectral data analysis.



Scheme 2.2: Synthesis of N- thiamido pyrazoline derivatives

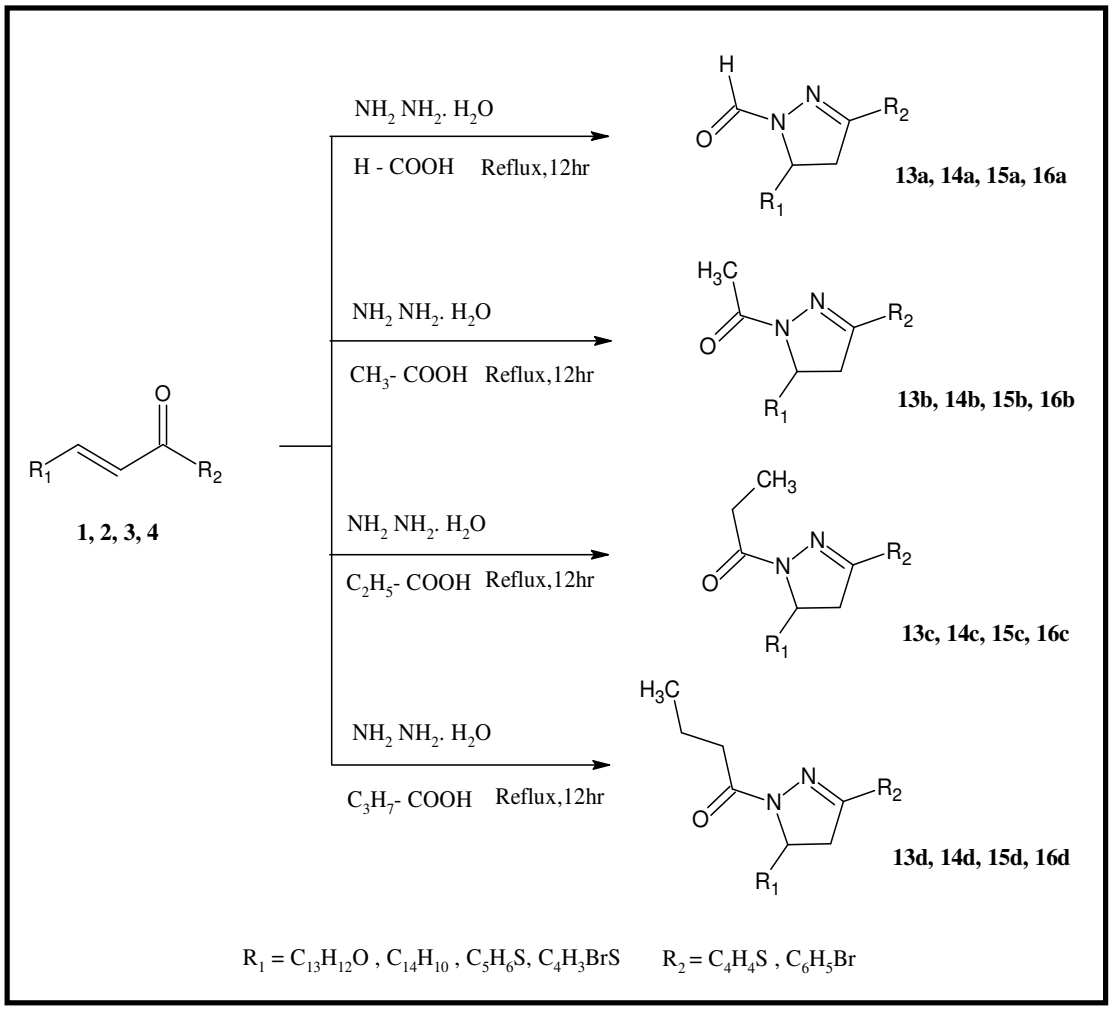
CHAPTER 3: STUDIES ON SYNTHESIS AND CHARACTERIZATION OF N- THIAZOLINYL PYRAZOLINE DERIVATIVES

In this chapter, synthesized the N-thaizolinyl pyrazoline derivatives (**Scheme 3**) by, N-thioamido pyrazoline derivatives and substituted 2-bromo-1-arylethanones in ethanol and refluxed for 12 hrs. The formations of the synthesized compounds were confirmed by FT-IR, ^{1}H NMR, ^{13}C NMR and LC-MS spectral data analysis.


9a, 10a, 11a, 12a
9b, 10b, 11b, 12b
9c, 10c, 11c, 12c
9d, 10d, 11d, 12d
9e, 10e, 11e, 12e
9f, 10f, 11f, 12f
5a, 6a, 7a, 8a
C2H5- OH
Reflux,6hr
R1 = C13H12O , C14H10 , C5H6S, C4H3BrS
R2 = C4H4S , C6H5Br
R3 = H , F, Cl, CH3, NO2, OCH3

Scheme 3.1: Synthesis of N- thaizolinyl pyrazoline derivatives

CHAPTER 4: STUDIES ON SYNTHESIS AND CHARACTERIZATION OF N-ALKOXY PYRAZOLINE DERIVATIVES



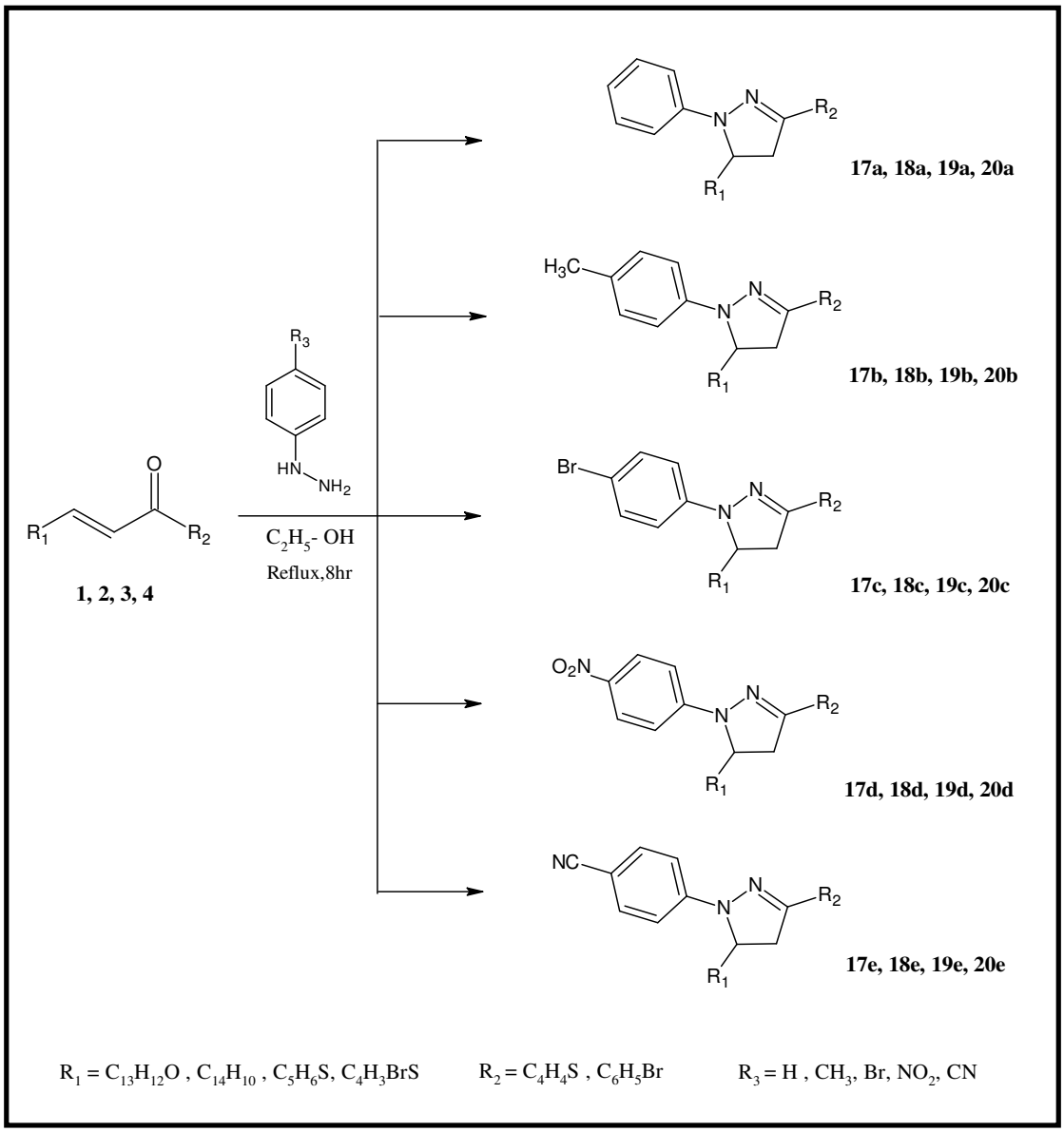
Scheme4.1: Synthesis of N-alkoxy pyrazoline derivatives

In this chapter, synthesized the N-alkoxy pyrazoline derivatives (**Scheme 4**) by, a mixture of chalcone derivatives and hydrazine hydrate in formic acid/acetic acid/ proponic acid / n-butyric acid were refluxed for 12 hr. The formations of the synthesized compounds were confirmed by FT-IR, ^{1}H NMR, ^{13}C NMR and LC-MS spectral data analysis. The single crystal XRD, Hirshfeld surface analysis of some N- alkoxy pyrazoline derivatives were carried out.

CHAPTER 5: STUDIES ON SYNTHESIS AND CHARACTERIZATION OF N-

N-ARYL PYRAZOLINE DERIVATIVES

In this chapter, synthesized the N-aryl pyrazoline derivatives (**Scheme 5**) by, a mixture of chalcone derivatives and substituted phenyl hydrazine in 10ml of ethanol was refluxed for 8 hrs. The formations of the synthesized compounds were confirmed by FT-IR, ^{1}H NMR, ^{13}C NMR and LC-MS spectral data analysis.



Scheme 5: Synthesis of N-aryl pyrazoline derivatives

CHAPTER 6: STUDIES OF PHOTOPHYSICAL AND BIOLOGICAL PROPERTIES

PART-A: STUDIES ON PHOTOPHYSICAL PROPERTIES

In this part, all the thienyl chalcone, N-thioamido pyrazoline, N-thiazolinyl pyrazoline, N-alkoxy pyrazoline and N-aryl pyrazoline derivatives were subjected to UV-Visible analysis and electronic band gap energy by Tauc's plot. Photoluminescence properties were analyzed. N- thiazolinyl, N-alkoxy and N-aryl pyrazoline derivatives had showed good photoluminescence properties. But thienyl chalcone and N-thioamido pyrazoline derivatives had not showed the photoluminescence property. In the basis of emission spectra, relative quantum yield was calculated with standard reference 9,10 DPA. In N-aryl pyrazoline derivative's series some of the compounds had exhibited excellent photoluminescence property with high relative quantum yield.

PART-B : STUDIES ON BIOLOGICAL PROPERTIES

In this part, all the thienyl chalcone, N-thioamido pyrazoline, N-thiazolinyl pyrazoline, N-alkoxy pyrazoline and N-aryl pyrazoline derivatives were tested for *in-vitro* antioxidant and anti-inflammatory activity. Among them, N-thiazolinyl pyrazoline series with phenyl and 4-methoxyphenyl substituted compounds showed good *in-vitro* antioxidant property with scavenging activity 83.3% and 80.8% respectively, against standard reference ascorbic acid and N-aryl pyrazoline derivatives substituted with 4 -cyanophenyl and 4-bromophenyl group showed good *in-vitro* anti-inflammatory activity with IC_{50} valve 17.6 and 18.5 respectively, against standard reference diclofenac sodium. Other newly synthesised derivatives had showed moderate results for both the activities.

Outcome of the work

- Synthesized 68 compounds namely thienyl chalcone, N-thioamido pyrazoline, N-thiazolinyl pyrazoline, N-alkoxy pyrazoline and N-aryl pyrazoline derivatives
- All the synthesized compounds were fully characterized by spectral studies and some of the compounds were analyzed by single crystal XRD studies
- The photophysical properties of newly synthesized compounds were analyzed by UV-Visible and photoluminescence spectroscopy
- N-aryl pyrazoline derivatives exhibited excellent photoluminescence property with high relative quantum yield
- All the Synthesized compounds were tested for *in-vitro* antioxidant and anti-inflammatory activity
- N-thiazolinyl pyrazoline derivatives exhibited potential *In-vitro* antioxidant activity
- N-aryl pyrazoline derivatives exhibited potential *In-vitro* anti-inflammatory activity

Reference:

[1] S.L. Gaonkar, U. N. Vignesh, Res.Chem. Intermed.,43 ,**2017**,6043-6077.

[2] C.G.D. Raj, B. K. Sarojini, S. Hegde, S. Sreenivasa, Y.S. Ravikumar, V. Bhanuprakash, Y. Revanaiah, R. Ragavendra, Med. Chem. Res., 22, **2013**, 2079–2087.

[3] D.K. Mahapatra, S.KBharti,V. Asati, Eur. J.Med.Chem., 98, **2015**,69-114.

[4] P.M. Shivakumar, P.K. Prabhakar, M. Doble, Med. Chem. Res., 20, **2011**, 482-492.

[5] C.E.Gutteridge, J.V. Vo, C.B. Tillett, J.A. Vigilante, J.R. Dettmer, S.L. Patterson, K.A. Werbovetz , J. Capers , D.A. Nichols , A.K. Bhattacharjee, L.Gerena, Med. Chem., 3, **2007**, 115-9.

[6] X. Fang,B. Yang,Z. Cheng ,P. Zhang ,M.Yang, Res.Chem.Interm.,40,**2014**,1715–1725.

[7] F.Herencia , M. L. Ferrfindiz , A. Ubeda , J. N. Dominguez , J. E. Charris , G.M. Lobo , M. J. Alcaraz, Bio.Med.Chem.Lettr. , 8, **1998**, 1169-1174.

[8] D. Gupta, D. K. Jain, J. Adv. Pharm. Technol. Res.,6, **2015**,114–117.

[9] P. Poornesh, S. Shettigar, G. Umesh, K.B. Manjunatha,K. PrakashKamath,. B.K. Sarojini,B. Narayana, Opt. Mat., 31, **2009**, 425-429.

[10] S. Shettigar, G. Umesh, K. Chandrasekharan, B.K. Sarojini, B. Narayana, Opt.Mat., 30, **2008**,1297-1303.

[11] H. M.Vagdevi, K. P.Latha, V. P.Vaidya,M. L.V.Kumar, K. S. R. Pai, Ind. J. Pharma. Sci., 63, **2001**, 286-291.

[12] M.Pandya, K.Kapadiya, C.Pandit, D.Purohit,J. Sci .Ind.Resch.,76, **2017**,173-178.

[13] S. Samshuddin, B. Narayana, B.K. Sarojini, R. Srinivasan,Vinayachandra,K.R. Chandrashekar, Der PharmaChemica 4,**2012**, 587-592.

[14] S. Samshuddin, B. Narayana, B.K. Sarojini, H.S. Yathirajan, R. Raghavendra, Der PharmaChemica 4, **2012**, 1445-1457.

[15] V.Monga, K.Goyal, M. Steindel, M. Malhotra, D. P. Rajani, S.D. Rajani, Med. Chem. Res., 23, **2014**, 2019–2032.

[16] B.K. Sarojini, B. Narayana, B.V. Ashalatha, J Cryst Growth 295, **2016**, 54-59.

[17] L. Kamath, K.B. Manjunatha, S. Shettigar, G. Umesh, B. Narayana, S. Samshuddin, B.K. Sarojini, Opt. Laser Technol. 56, **2014**, 425-429.

[18] S. Shettigar, G. Umesh, K. Chandrasekharan, B.K. Sarojini, B. Narayana, Polymer 47, **2006**, 3565-3567.

[19] Rigaku, CrystalClear SM Expert. Rigaku Corporation, Tokyo, Japan.**2011**

[20] G.M. Sheldrick, ActaCrystallogr. A A64 (2008) 112-122. (b) G.M. Sheldrick, ActaCrystallogr. C C71, **2015**, 3-8.

[21] C.F. Macrae, I.J. Bruno, J.A. Chisholm, P.R. Edgington, P. McCabe, E. Pidcock, L. Rodriguez-Monge, R. Taylor, van de Streek J, P.A. Wood, J. Appl. Crystallogr. 41, **2008**, 466-470.

[22] B. Sever , C. Türkes , M. D. Altıntop, Y. Demir, Inter. J. Bio. Macro., 163, **2020**,1970–1988

[23] S. M. Kumar, B. C. Manjunath, G. S. Lingaraju, M. M. M. Abdoh, M. P. Sadashiva, N. K. Lokanath, Crystal Structure Theory and Applications, **2013**, 2, 124-131.

[24] A. d. Vasconcelos, V. F. Campos, F. Nedel, F. K.Seixas, Cell.Biochem.Funct,**2012**.

[25] N.K. Sahu, S.S. Balbhadra, J. Choudhary and D.V. Kohli, Current Medicinal Chemistry, 19,**2012**, 209-225.

[26] V.V. Salian, B. Narayana,B. K. Sarojini, E. S. Sindhupriya, L. N. Madhu, S. Rao, Lett. Drug Des. Disc., 14, **2017**, 216-227.

[27] L. Benmekhbi, S. Mosbaha,A. K. baghdoucha, L. bencharif, Orient. J. Chem., 31,**2015**, 1395-1402.

[28] U.Tutar, C. Celik, H.Gezegen, C.Hepokur, Cumh.Med.J., 39, **2017**,466-472.

[29] M. Gaber, S.A. El-Daly, T.A. Fayed, Y.S. El-Sayed, Opt. Las. Techn., 40, **2008**, 528‑537.

[30] K. Rurack, J. L. Bricks, G. Reck,J. Phys. Chem.A., 104, **2000**, 3087-3109.

[31] K.Yamada, H.Shosenji, Y.Nakano, M.Uemura, S.Uto, M.Fukushima, Dye. An.Pig.,2, **1981**, 21-29.

[32] P. Stakhira, S. Khomyak, V. Cherpak, D. Volyniuk, J. Simokaitiene , A. Tomkeviciene , N.A. Kukhta, J.V. Grazulevicius, A.V. Kukhta, X.W. Sun, H.V. Demir, Z. Hotra, L. Voznyak, Synth. Met.,162, **2012**, 352-355.

[33] N.M.Stefanes,J.Toigo, M. F. Maioral, A. V. Jacques,L. D.C.Delatorre, D.M.Perondi,A. A. B. Ribeiro, A. Bigolin, I. M. S. Pirath,B.F.Duarte, R.J.Nunes, M.C.S.Silvaruna, Bioorg. Med. Chem.,27, **2019**, 375-382.

[34] S. Kuthyala, M. Hanumanthappa, S. M.Kumar, S. Sheik, N. G. Karikannar , A. Prabhu, J.Mol.Struct.,1197,**2019**, 65-72.

[35] M.Johnson,B.Younglove,L.Lee,R.L.Blanc,H.H.Jr,P.Hills,H.Mackay,T.Brown,S.L .Mooberry,M. Lee, Bioorg. Med. Chem. Lett.,17, **2007**,5897-5901.

[36] V. V Salian, B. Narayana, B. K Sarojini, M. S Kumar, G. S Nagananda, K. Byrappa, A. K.Kudva, Spectr. Acta Part A: Mol.Biomol.Spectr., 174, **2015**,254-271.

[37] B. Varghese , S. N. Al-Busafi , F. O. Suliman, S. M. Z. Al-Kindy, RSC Adv., 7, **2017**,46999-47016.

[38] V.V.Salian,B.Narayana, B K.Sarojini,M.S.Kumar,K.S.Chandra,A.G.Lobo, J. Mol.Struct. 1192, **2019**, 91-104.

[39] M.Sapnakumari, B. Narayana, P. M. Gurubasavarajswamy, B. K. Sarojini, Monats.fürChemie-Chem,lMonth.,146, **2015**,1015-1024.

[40] J. P. Sethiya, S. P. Bhavsar and H. V. Shahare, Int.J.Pharm.Sci.res.,18, **2019**, 3290-3294.

[41] S. Samshuddin, B.Narayana, B. K. Sarojini, M. T.H. Khan, H. S. Yathirajan, C. G.Darshan Raj, R.Raghavendra,Med. Chem. Res., 21, **2012**, 2012–2022.

[42] M. Kharbanda, M.S. Alam,H. Hamid,K. Javed, S.Shafi, Y. Ali, P. Alam, M.A.Q. Pasha,Bioorg. Med. Chem. Lett., 24,**2014**, 5298-5303.

[43] D.C. Manvar,J.M. Parmar, J. Chem. Pharm. Res., 7, **2015**, 475-478

[44] A. Ozdem, G.T. Zitouni, Tur. J.Chem, 32, **2008** , 529 – 538.

[45] V. Ramkumar, P. Kannan, J. Lumin.,**2015**, S0022-2313(15)00525-6.

[46] G.Bai, J. Li, D.Li, C. Dong, Dy. Pig., 75, **2007**, 93e98

[47] P.K. Deb, R. Kaur , B.Chandrasekaran ,M. Bala, Med.Chem. Res., 23, **2014**, 2780–2792.

[48] Q.F. Wu,B. Zhao, Z.J. Fan, J. B. Zhao, X. F.Guo, RSC Adv., 8, **2018**,39593–39601.

[49] A.R. Sayed, S.M. Gomha ,E. A. Taher, Z. A. Muhammad, Dr.Desi. Devel. Ther.,**2020**,14.

[50] R. E. Khidre, I. A. M. Radini, Sci. Rep., 11,**2021**, 7846.

[51] R. M. Mohare, A. E. M. Abdallah, M. A. Abdelaziz, Med. Chem. Res.,23, **2014**, 564–579.

[52] M.M. Edrees, S. Abu-Melha, A.M. Saad, N.A. Kheder, S.M. Gomha, Z.A. Muhammad, Molecules 23, **2018**, 2970.

[53] V. V Salian, B. Narayana, B. K Sarojini, M. S Kumar, K S.h Chandra, A. G Lobo, J. Mol. Str., 1192, **2019**, 91-104

[54] M. Tugrak, H. I. Gul,H. Sakagamu, I. Gulcin, J. Het. Chem.,**2020**, 1–7.

[55] N. Svanvik, G. Westman, D. Wang, M. Kubista Analytical Biochemistry 281, **2000**, 26–35

[56] Z. Lin, Z.Y.Wang, X. Zhou, M. Zhang, Cel. De. Dis., **2020**, 11:551

[57] S. D. Choudhury, A.C. Bhasikuttan, H. Pal, J. Mohanty, Lang., **2011**, 27, 12312–12321

List of research paper published/Accepted/Communicated in national/international journals, poster presentation and conferences attended

Paper Published:

1. P. Praveena, B. K. Sarojini, Q.A. Wong, C. K. Quah, T. Vishwanath, Synthesis, characterization, single crystal XRD, Hirshfeld surfaces, 3D energy framework calculations and DFT studies of ethanone and propanone derivatives of *N*-substituted pyrazoline, J.Mol.Str.,2021,1239, 5,130524.

2. P. Praveena, B.K. Sarojini, S.M. Kumar, Mechanochemical synthesis and characterizations of chalcone derivatives:(2E)-3-[4-(Benzyloxy) phenyl]-1-(thiophen-2-yl) prop-2-en-1-one and (2E)-3-(Anthracen-9-yl)-1-(thiophen-2-yl) prop-2-en-1-oneChem.Dat. Collectn.,2019,24,100298.

Poster presentation:

1. "Preparation & Characterization of ZnO Nanoparticles"in National Seminar and Workshop on Functional Nanomaterials for Energy, environment and health organized by Department of Industrial Chemistry, Mangalore University, Mangalagangothri. 21st - 22nd March 2016.

Conferences attended:

1. Workshop on "Biological Diversity Act-2002" and Interaction Meeting of Bioresource Users for Research organized by Karnataka Biodiversity Board, Mangalore University. 31st January 2015.

2. "International Workshop on Drug Development and Neglected Tropical Infectious Diseases" organized by CAS in Crystallography and Biophysics, University of Madras, Guindy Campus, Chennai. 22nd -27th February 2015.

3. National Workshop on Structure Based Drug Designing" organized by CAS in Crystallography and Biophysics and Bioinformatics Infrastructure Facility (DBT Funded), University of Madras, Guindy Campus, Chennai. 28th February- 1st March 2015.

4. Seminar on Research Methodology, organized by Vivekananda Centre for Research Studies, Puttur. 16th October 2015.

5. National conference on Recent Trends in Chemical Sciences organized by Department of Chemistry, Manipal Institute of Technology, Manipal University. 11th -12th January 2016.

6. National Seminar and Workshop on Functional Nanomaterials for Energy, environment and health organized by Department of Industrial Chemistry, Mangalore University, Mangalagangothri. 21st - 22nd March 2016.

7. National Workshop on Emerging Targets and Biomarkers in Cancer Therapy organized by CARRT, Mangalore University, Mangalagangothri. 16th -18th May 2016.

8. STEM FEST, 3rd International Festival of Science, Technology, Engineering and Mathematics-2016, International STEM Alliance, Organized by University of Mysore. 17-20th October 2016.

9. Creativity World Forum (CWF)-2016 Conference on "Cities In Transition", held at Bengaluru. Organized by Karnataka State Higher Education Council. 28th-30th November 2016.

10. One day seminar on "Emerging Solar PV Technology Applications for Academics", held at Mangalore University campus. Organized by Mangalore University in association with kWatt Solutions Pvt. Ltd, IIT, Mumbai. 3rd December 2016.

11. Nanofibers and their applications (GAIN short course) organized by CARRT, Mangalore University, Mangalagangothri. 27th February – 7th March 2017.

12. National conference on "Reaching and Unreached through Science and Technology: Recent advances in Physical, Chemical, Mathematical and biological Science for Energy, Health and Environment" organized by Mangalore University, Mangalagangothri and The Indian Science Congress Association - Bangalore Chapter, India. 8th - 9th September 2017.

(Praveena P.)	(Prof. B. K. Sarojini)
Signature of the Research Scholar	Signature of the Research Guide